

**APPOMATTOX COURT HOUSE NATIONAL  
HISTORICAL PARK  
GEOLOGIC RESOURCE MANAGEMENT ISSUES  
SCOPING SUMMARY**

Trista L. Thornberry- Ehrlich  
Colorado State University – Geologic Resource Evaluation  
April 21, 2005



The courthouse at Appomattox Court House National Historical Park near Appomattox, Virginia. Photograph by Landry C. Thornberry, 2005.

## ***Table of Contents***

Executive Summary .....	4
Introduction .....	5
Physiography .....	7
Geologic History of Central Virginia .....	8
Stratigraphy .....	12
Structure .....	13
Significant Geologic Resource Management Issues at Appomattox Court House National Historical Park .....	14
Scoping Meeting Participants .....	21
References .....	22
Map of Appomattox Court House National Historical Park .....	24

## ***Executive Summary***

A Geologic Resources Evaluation scoping meeting for Appomattox Court House National Historical Park took place at Petersburg National Battlefield in Petersburg, VA on April 14, 2005. The scoping meeting participants identified the following list of geologic resource management issues. These topics are discussed in detail on pages 14- 20.

1. Surface water quality at the headwaters of the Appomattox River is important to understand and monitor for the rest of the watershed
2. Seismic hazards
3. Erosion and slope processes
4. Geologic hazards including swelling soils
5. Connections between geology, biology, and the Civil War history to appeal to visitors interested in a deeper connection to the landscape
6. Human impacts including power lines, cattle grazing, nearby industry, increasing development
7. Mine- related features such as quarries, sand and gravel borrow pits
8. Hydrogeologic system characterization and groundwater quality to protect drinking supplies and understand how contaminants are moved through the system
9. Future facilities development and characterization with regards to geologic factors such as swelling clays and groundwater flow conduits

## ***Introduction***

The National Park Service held a Geologic Resource Evaluation scoping meeting for Appomattox Court House National Historical Park in Petersburg National Battlefield in Petersburg, Virginia on Thursday, April 14, 2005. The purpose of the meeting was to discuss the status of geologic mapping in the park, the associated bibliography, and the geologic issues in the park. The products to be derived from the scoping meeting are: (1) Digitized geologic maps covering the park; (2) An updated and verified bibliography; (3) Scoping summary (this report); and (4) A Geologic Resource Evaluation Report which brings together all of these products.

Appomattox Court House National Historical Park was designated U.S. War Department Battlefield Site on June 18, 1930 under Herbert Hoover's Administration. It was later redesignated a National Historical Monument on August 13, 1935 under Franklin D. Roosevelt. The park attained National Historical Park status on April 15, 1954 during Dwight D. Eisenhower's administration. The park preserves the setting of the end of the Civil War. In 1865, Confederate forces fleeing the siege of Petersburg met with Union troops. Forced to defeat, Confederate General Robert E. Lee surrendered to Union General Ulysses S. Grant at the home of Wilmer and Virginia McLean in the small village of Appomattox Court House. Appomattox Court House National Historical Park covers 1,774 acres. It protects a portion of the Appomattox River watershed, not to mention the historical landscape features including Appomattox County Courthouse, McLean House, Meeks' Store, Appomattox County Jail, Lee's and Grant's headquarters, and a Confederate cemetery.

Appomattox Court House National Historical Park identified 2 quadrangles of interest, the Vera and Appomattox 7.5'x7.5' quadrangles. These quadrangles are all contained within the 30'x60' 1:100,000 Appomattox sheet. No known 1:1 map coverage for the quadrangles or sheet exists. However, the Virginia Division of Mineral Resources (VDMR) is interested in initiating some new mapping in the area as part of their 10 year State Map program. The VDMR 1993, 1:500,000 scale map could be used in the interim, and additional information relevant to the area could be added to this coverage as reconnaissance mapping increase resolution of geologic map units. A definite time schedule has not been established.

Many other maps exist for the region that include coverage of the geology, oil and gas features, surficial geology, topography, groundwater features, land use, Landsat imagery, geochemical features, aeromagnetic- gravity, mineral and mineral potential, hazard features, stratigraphy, hydrogeology, structures, glacial features, karst features, etc. The maps are available from agencies such as the U.S. Geological Survey, the Virginia Division of Mineral Resources, the Geological

Society of America, the American Geological Institute, the Maryland Geological Survey, the West Virginia Geological and Economic Survey, and the West Virginia Geological Survey. Additional mapping at a smaller scale (1:6,000 ideally) within park boundaries will be more helpful for park resource management and interpretation.

## ***Physiography***

Appomattox Court House National Historical Park lies within the western Piedmont Plateau physiographic province. In the area of Appomattox, Virginia, the eastern United States is divided into 5 physiographic provinces with associated local subprovinces. These are, from east to west, the Atlantic Coastal Plain, the Piedmont Plateau, the Blue Ridge, the Valley and Ridge, and the Appalachian Plateaus provinces.

The eastward- sloping Piedmont Plateau is located between the Blue Ridge province along the eastern edge of the Appalachian Mountains and the Atlantic Coastal Plain province to the east. It formed through a combination of folds, faults, uplifts, and erosion. The resulting landscape of eastern gently rolling hills starting at 60 m (197 ft) in elevation becomes gradually steeper westward toward the western edge of the province and reaches 300 m (984 ft) above sea level. The Piedmont Plateau is composed of hard crystalline, igneous, and metamorphic rocks such as schists, phyllites, slates, gneisses, and gabbros. Soils in the Piedmont Plateau are highly weathered and generally well drained. The “Fall Line” or “Fall Zone” marks a transitional zone where the softer, less consolidated sedimentary rock of the Coastal Plain to the east intersects the harder, more resilient metamorphic rock to the west to form an area of ridges, waterfalls, and rapids.

The Atlantic Coastal Plain province is primarily flat terrain with elevations ranging from sea level to about 100 m (300 ft) in Maryland. Sediments eroding from the Appalachian Highland areas to the west formed the wedge- shaped sequence of soft sediments that were deposited intermittently during periods of higher sea level over the past 100 million years. These sediments are now more than 2,438 m (8,000 ft) thick at the Atlantic coast and are reworked by fluctuating sea levels and the continual erosive action of waves along the coastline. Large streams and rivers in the Coastal Plain province, including the James, York, Rappahannock, and Potomac, continue to transport sediment and to extend the coastal plain eastward. Beyond the province to the east is the submerged Continental Shelf province for another 121 km (75 miles).

The Blue Ridge contains the highest elevations in the Appalachian Mountain system. These are in Great Smoky Mountains National Park in North Carolina and Tennessee. Precambrian and Paleozoic igneous, sedimentary, and metamorphic rocks were uplifted during several orogenic events to form the core of the mountain range. Today this comprises the steep, rugged terrain now exposed after millions of years of erosion. Characteristics of the Blue Ridge province include steep terrain covered by thin, shallow soils, resulting in rapid runoff and low ground water recharge rates.

## ***Geologic History of Central Virginia***

Proterozoic Era – In the mid Proterozoic, during the Grenville orogeny, a supercontinent (Rhodinia) formed which included most of the continental crust in existence at that time. This included the crust of North America and Africa. The sedimentation, deformation, plutonism (the intrusion of igneous rocks), and volcanism associated with this event are manifested in the metamorphic gneisses in the core of the modern Blue Ridge Mountains (Harris et al., 1997). These rocks were deposited over a period of a 100 million years and are more than a billion years old, making them among the oldest rocks known from this region. They form a basement upon which all other rocks of the Appalachians were deposited (Southworth et al., 2001).

The late Proterozoic, roughly 600- 700 million years ago, brought a tensional, rifting tectonic setting to the area. The supercontinent broke up and a sea basin formed that eventually became the Iapetus Ocean. In this tensional environment, flood basalts and other igneous rocks such as diabase and rhyolite added to the North American continent. These igneous rocks were intruded through cracks in the granitic gneisses of the Blue Ridge core and extruded onto the land surface during the break- up of the continental land mass (Southworth et al., 2001). Today these flood basalts comprise the Catoctin Greenstone. The Iapetus basin collected many of the sediments that would eventually form the Appalachian Mountains and Piedmont Plateau. These deposits interfingered with mid-oceanic rift volcanic deposits.

### Early Paleozoic Era –

From Early Cambrian through Early Ordovician time orogenic activity along the eastern margin of the continent began again. The Taconic orogeny (~440- 420 Ma in the central Appalachians) was a volcanic arc – continent convergence. Oceanic crust, basin sediments, and the volcanic arc from the Iapetus basin were thrust onto the eastern edge of the North American continent. The basin deposits interlayered with mid ocean ridge volcanics were in effect trapped between the continent and the island arcs (referred to as the Avalon exotic terranes) and were folded and faulted during the orogeny.

The Taconic orogeny involved the closing of the ocean, subduction of oceanic crust, the creation of volcanic arcs and the uplift of continental crust (Means, 1995). Rocks of the western Piedmont were shoved westward along the Central Piedmont Suture (detachment) (Clark, meeting communication, 2005). Horizontal displacement estimates are approximately 50- 200 km. Far below the rocks of the western Piedmont are carbonates exposed at the surface in the western Valley and Ridge physiographic province. Initial metamorphism of the

Catoctin Formation into metabasalts and metarhyolites, as well as the basin sediments of the western Piedmont (graywackes) into quartzites and phyllites occurred during this orogenic event.

In response to the overriding plate thrusting westward onto the continental margin of North America, the crust bowed downwards to the west creating a deep basin that filled with mud and sand eroded from the highlands to the east (Harris et al., 1997). This so-called Appalachian basin was centered on what is now West Virginia. These infilling sediments are today represented by the shale of the Ordovician (450 Ma) Martinsburg Formation (Southworth et al., 2001).

During the Late Ordovician, the oceanic sediments of the shrinking Iapetus Ocean were thrust westward onto other deepwater sediments of the western Piedmont. Sandstones, shales, siltstones, quartzites, and limestones were continuously deposited in the shallow marine to deltaic environment of the Appalachian basin. These rocks, now metamorphosed, currently underlie the Valley and Ridge province (Fisher, 1976).

This shallow marine to fluvial sedimentation continued for a period of about 200 My during the Ordovician, Silurian, Devonian, Mississippian, Pennsylvanian, and Permian Periods. This resulted in thick piles of sediments. The source of these sediments was from the highlands that were rising to the east during the Taconian orogeny (Ordovician), and the Acadian orogeny (Devonian).

The Acadian orogeny (~360 Ma) continued the mountain building of the Taconic orogeny as the African continent approached North America (Harris et al., 1997). Similar to the preceding Taconic orogeny, the Acadian event involved land mass collision, mountain building, and regional metamorphism (Means 1995). This event was focused further north than central Virginia.

Late Paleozoic Era – Following the Acadian orogenic event, the proto- Atlantic Iapetus Ocean was completely destroyed during the Late Paleozoic as the North American continent collided with the African continent. This formed the Appalachian mountain belt we see today and a supercontinent named Pangaea. This mountain building episode is called the Alleghanian orogeny (~325 – 265 Ma), the last major orogeny of the Appalachian evolution (Means, 1995). The deformation by folding and faulting produced the Sugarloaf Mountain anticlinorium and the Frederick Valley synclinorium in the western Piedmont, the Blue Ridge- South Mountain anticlinorium, and the numerous folds of the Valley and Ridge province (Southworth et al., 2001).

During this orogeny, rocks of the Great Valley, Blue Ridge, and Piedmont provinces were transported as a massive block (Blue Ridge – Piedmont thrust sheet) westward onto younger rocks of the Valley and Ridge along the North

Mountain fault. The amount of compression was extreme. Estimates are of 20-50 percent shortening which translates into 125-350 km (75- 125 miles) of lateral translation (Harris et al., 1997).

Deformed rocks in the eastern Piedmont were also folded and faulted and existing thrust faults such as the Central Piedmont Suture were reactivated as both strike slip and thrust faults during the Alleghanian orogenic events (Southworth et al., 2001; Carter, meeting communication, 2005). Paleoelevations of the Alleghenian Mountains are estimated at approximately 6,096 m (20,000 ft), analogous to the modern day Himalaya Range in Asia.

Mesozoic Era – Following the Alleghenian orogeny, during the late Triassic, a period of rifting began as the deformed rocks of the joined continents began to break apart from about 230- 200 Ma. The supercontinent Pangaea was segmented into roughly the continents that persist today. This episode of rifting or crustal fracturing initiated the formation of the current Atlantic Ocean and caused many block- fault basins to develop with accompanying volcanism (Harris et al., 1997; Southworth et al., 2001). These Mesozoic basins are scattered around the park area.

Thick deposits of unconsolidated gravel, sand, and silt were shed from the eroded mountains. These were deposited at the base of the mountains as alluvial fans and spread eastward to be part of the Atlantic Coastal Plain (Duffy and Whittecar 1991; Whittecar and Duffy, 2000; Southworth et al., 2001). The amount of material inferred from the now- exposed metamorphic rocks is immense. Many of the rocks exposed at the surface must have been at least 20 km (~10 miles) below the surface prior to regional uplift and erosion. The erosion continues today with the Potomac, Rappahannock, James, Rapidan, and Shenandoah Rivers, stripping the Coastal Plain sediments, lowering the mountains, and depositing alluvial terraces of the rivers, creating the present landscape.

Cenozoic Era – Since the breakup of Pangaea and the uplift of the Appalachian Mountains, the North American plate has continued to drift toward the west. The isostatic adjustments that uplifted the continent after the Alleghenian orogeny continued at a subdued rate throughout the Cenozoic Period (Harris et al., 1997). These adjustments may be responsible for occasional seismic events felt throughout the region.

Though glaciers from the Pleistocene Ice Ages never reached the central Virginia area (the southern terminus was in northeastern Pennsylvania), the intermittent colder climates of the ice ages played a role in the formation of the landscape at Appomattox Court House National Historical Park. Freeze and thaw cycles at higher elevations led to increased erosion of large boulders and rocks by ice

wedging. Sea level fluctuations during ice ages throughout the Pleistocene caused the baselevel of many of the area's rivers to change. During lowstands (sea level drops), the rivers would erode their channels exposing the deformed bedrock of the Piedmont Plateau. During oceanic highstands, the river basins flooded and deposition resulted in deposits of beach sediments far west of the present shoreline.

## ***Stratigraphy***

Appomattox Court House National Historical Park sits on the western portion of the Piedmont Plateau physiographic province. This portion of the Piedmont contains metamorphosed and deformed distal marine sediments deposited within the Iapetus basin interlayered with mid-oceanic rift sediments.

Bedrock exposures within the park are rare. The oldest rocks in the Appomattox Court House National Historical Park are exposed along the deepest eroded reaches of the Appomattox River. According to the VDMR's 1993 Geologic map of Virginia, within the park's quadrangles of interest is a belt of felsic metavolcanic rocks including felsic metatuff, mica schist, and gneiss. This belt is contained within a larger zone of mafic metavolcanics including greenstones and amphibolite. Along the western edge of the area is the Fork Mountain Formation that contains porphyroblastic aluminosilicate mica schist, garnetiferous biotite gneiss, and amphibolite.

Several Mesozoic age extension basins including the Farmville Mesozoic Basin exist around the Appomattox area to the east. These basins formed during crustal extension accompanying the formation of the Atlantic Ocean. These basins were typically bounded by linear normal faults. The basins flooded and filled with sediments and were occasionally intruded by diabase dikes. The Farmville Mesozoic Basin contains sediments including sands, gravels, silts, and muds eroded from the Appalachian highlands.

The youngest deposits at Appomattox Court House National Historical Park include thick alluvium deposits of sand, gravel, silt and clays, marsh and swamp deposits along larger rivers, terrace deposits atop higher areas, and artificial fill from construction of roads, dams, bridges, landfills, and highways.

## **Structure**

Appomattox Court House National Historical Park sits within the Western Piedmont. This subprovince is separated from the Central Virginia Volcanic-Plutonic Belt subprovince by several reactivated thrust faults and Mesozoic extensional basins including the Danville Mesozoic basin to the southeast, the Brookneal fault zone, and the Shores melange zone. On the western edge of Appomattox County, the Western Piedmont abuts the Proterozoic Blue Ridge physiographic province rocks. The park sits atop Paleozoic intrusive granite, quartz monzonite, and granodiorite rocks that are surrounded by Cambrian-Ordovician polydeformed metasedimentary schist, phyllite, gneiss, and metagraywacke.

Parallel thrust faults, trending northeast- southwest and in places reactivated in a normal sense cut through the center of Appomattox County. Prominent among these is the Bowens Creek fault that is a Paleozoic high- strain zone. This sheared zone further north of Appomattox is called the Mountain run zone and trends northeast just east of Charlottesville (Bailey, 2000). Here the shear zone separates the Western Piedmont from the Blue Ridge physiographic province.

Small- scale joints and fractures are ubiquitous in the rocks beneath Appomattox Court House. Most follow the northeast- southwest regional trend, possibly due to Mesozoic extensional events.

## ***Significant Geologic Resource Management Issues at Appomattox Court House National Historical Park***

### **I. Surface water quality**

One of the major goals of the park is to present the historical context of the area; this includes preserving and restoring any old buildings and the landscape around them. Maintaining this Civil War landscape often means resisting natural geologic changes, which presents several management challenges. Geologic slope processes such as chemical weathering, and slope erosion are constantly changing the landscape at the park. Alterations to park vegetation along exposed slopes lead to changes in the hydrologic regime at the park. For example, clearing of trees and their stabilizing roots for historical restoration, can lead to increased erosion, thereby increasing sediment load in nearby streams.

The river and other local streams are changing position constantly as part of natural meandering river flow. These shoreline changes threaten existing park facilities and the historical context of the landscape. Storm events including microbursts and thunderstorms, can send torrents of rain in a very localized area. Such storms are responsible for debris flows along slopes of the Blue Ridge Mountains and can cause slumping and landsliding on even moderate slopes.

Many waterways cross the landscape within and surrounding Appomattox Court House National Historical Park. These include the Appomattox River, North Branch, Plain Run Branch, and Rocky Run. A portion of the headwaters for the Appomattox River is contained within park boundaries. Because of this, the quality of the surface water at the park is very important to park management and by extension, the surrounding communities. Flooding and channel erosion are naturally occurring along most of the streams and rivers within the park.

Several riparian wetlands exist within the park and are threatened by increased flow and floods, as well as by sediment loading. Though small in scale at Appomattox Court House, wetlands are typically considered indicators of overall ecosystem health and should be researched and monitored periodically. Surface water quality at the park is threatened by ground compaction due to increased use as well as increases in impervious surfaces such as parking lots and roadways. These features increase the amounts of seasonal runoff as sheet flow.

Research and monitoring questions and suggestions include:

- Identify areas prone to slope failure during intense storm events.
- Monitor erosion rates and shoreline changes along the Appomattox River and compare to previous conditions using aerial photographs where available.

- What are the effects of increased erosion on aquatic ecosystems at the park?
- Is runoff in the park increasing due to surrounding development? If so, are there any remedial efforts the park can undertake to reduce this impact?
- Should the park preserve (recreate) historic landscapes at the expense of natural processes?
- Should the park target certain areas for restoration and leave others to natural processes?
- Develop an interpretive program detailing the balance between cultural context and natural processes at Appomattox Court House National Historical Park.
- Monitor water and soil quality in wetlands to establish as basis for comparison of future conditions.
- Use aerial photographs to study changes to wetland distribution through time.
- Determine any hotspots for water contamination. Remediate and monitor results.
- Research planting new vegetation along vulnerable reaches of park streams to prevent excess erosion and sediment loading.

## 2. Seismic hazards

Seismic events are not unheard of at Appomattox Court House National Historical Park. In 2003, a 4- 4.8 magnitude earthquake occurred in the area. Possibly due to crustal relaxation (isostatic adjustment), earthquakes are not uncommon in the eastern United States. In addition to the ground shaking associated with earthquakes are landslides, damage to buildings and other manmade structures, ground and surface water disturbances, etc. Though the probability of a destructive seismic event at the park is low, resource management should be made aware of the potential.

Research and monitoring questions and suggestions include:

- Work with local universities and government agencies to monitor seismic activity in the area.
- Perform stability measurements of local slopes and historic building foundations to help predict possible responses to seismic events.

## 3. Erosion and slope processes

The topographic differences within and surrounding the historical park appear small and insignificant. However, the likelihood of landslides and slumps increases with precipitation and undercutting of slopes by streams, roads, trails, and other development in addition to natural erosion. Using a topographic map to determine the steepness of a slope, a geologic map to determine the rock type,

and rainfall information, one could determine the relative potential (risk) for landslide occurrence.

Severe weather is difficult to predict. This area of Virginia can receive large amounts of snow and is in a hurricane- affected zone. Periodic flooding of the Appomattox River is the result of sudden, large inputs of precipitation. This extreme weather combined with moderate slopes, loose, unconsolidated soils and substrate can lead to sudden slope failures. In the vicinity of streams and rivers, this leads to shoreline erosion, increased sediment load, gullying, and threat of destruction for trails, bridges and other features of interest.

Increased erosion along the outer portions of bends in streambeds (where stream velocity is higher), causes the bank to retreat, undercutting the bank leading to washout. Trees, trails, and other features along these banks are undermined. Trees fall across the stream and trails are washed out. Remedial structures such as cribbing, log frame deflectors, jack dams, stone riprap, and/or log dams can shore up the bank, deflect the flow, and help to slow erosion (Means, 1995).

Research and monitoring questions and suggestions include:

- Use shallow (10- inch) and deeper core data to monitor rates of sediment accumulation and erosion in the river, local streams, and springs.
- Monitor erosion rates by establishing key sites for repeat profile measurements to document rates of erosion or deposition, and reoccupy if possible shortly after major storm events. Repeat photography may be a useful tool.
- Perform a comprehensive study of the erosion and weathering processes active at the park, taking into account the different sediment deposit compositions versus slope aspects, location and likelihood of instability.
- Inventory runoff flood susceptible areas (paleoflood hydrology), relate to climate and confluence areas

#### 4. Geologic hazards

Swelling soils occur in the Appomattox County area. Swelling soils (clays) expand when water saturated and shrink when dry. These soils are usually derived from weathered amphibolitic rocks, such as those present beneath the park. In extreme cases, these soils can undermine roads, buildings, and other structures. In less extreme ways, they can affect trails and other visitor use facilities.

Research and monitoring questions and suggestions include:

- Map locations of high swelling clay concentrations to avoid for future development.

- Perform a clay content survey to better understand soils and identify areas of swelling clay problems.

## 5. Connections between geology, biology, and the Civil War history

In many Civil War maneuvers, it was the advantage that familiarity with terrain, preparation to utilize of the natural features of the area, and the manipulation of the focal points, the gaps, ravines, cuts, hills, and ridges gave to one side or another that was to decide the outcome. The rolling hills and gentle landscape and topography at Appomattox Court House National Historical Park are defined by the geology and hydrology. This setting dictated the placement of the towns, strategy and encampment of troops, escape routes, river crossings, railroads, and the development of outlying areas. In addition to influencing battles, the landscape and topography also affected how troops and supplies were transported during the Civil War. Because Appomattox Court House is famous for the sight of Lee's surrender, geologic controls on the landscape and Civil War story are overlooked.

Runoff erodes sediments from any open areas and carries them down streams and gullies. Erosion naturally diminishes higher areas such as ridges and hills, foundations, earthworks, degrades bridge foundations, erodes streams back into restoration areas, and fills in the lower areas such as trenches, railroad cuts and stream ravines distorting the historical context of the landscape.

Interpreters make the landscape come alive for visitors and give the scenery a deeper meaning. Because geology forms the basis of the entire ecosystem, it is directly responsible for the history at Appomattox Court House National Historical Park. Thus, geologic features and processes should be emphasized to improve the visitor's experience.

The geology, in direct correlation with the soil types present at the park also controls natural biologic patterns in trees and other plants. The geologic units at Appomattox Court House National Historical Park include mafic metavolcanics and amphibolites. These calcium rich rocks weather to create fertile soils that attract specific native plants. For example, the American red cedar and redbuds prefer calcium rich substrates to grow in. The website for the park needs to be updated for geologic content and connections with other scientific (biology) and cultural disciplines.

Research and monitoring questions and suggestions include:

- Create interpretive programs concerning geologic features and processes and their effects on the Civil War history of the park.

- Perform and encourage outside research towards understanding geologic controls of plant distribution patterns within the park and surrounding areas.
- Encourage the interaction between geologists and the interpretive staff to come up with a list of features and programs to execute.
- Create a general interest map for visitors containing simple explanatory text on the geologic influences on troop movements.
- Update the park website relating geology with other resources.

## 6. Human impacts

The area surrounding Appomattox Court House National Historical Park is becoming increasingly populated. As development continues, conservation of any existing forest- meadow community types becomes a critical concern. Understanding the geology beneath the biotic communities becomes vital to their management. Park management of the landscape for historic preservation purposes compliments the preservation of these forests.

Humans began settling the Appomattox area in the 1700's, stemming from the earliest settlements further east in the Richmond area heading west towards the Blue Ridge. Their farming and homestead activities created an unnatural landscape that persists today at Appomattox Court House National Historical Park. Removal of soil and rocks, grazed pastures, and homestead sites dot the landscape.

Human impacts continue today as water lines, gas lines, power lines, radio towers, industrial complexes (along the southern boundary of the park), roads, and housing developments increase on the landscape. Cattle grazing on leased lands within and adjacent to the park threaten surface and groundwater quality as well as increases streambank erosion. Additionally, trails, visitor use areas, imported (invasive species), acid rain, and air and water pollution take their toll on the landscape. Resource management of these impacts is an ongoing process.

Research and monitoring questions and suggestions include:

- Perform acid rain measurements and correlate with the underlying bedrock to determine if any buffering effects occur. Relate this information to the water quality for the park.
- Are soils becoming more acidic due to acid rain?
- Monitor chemical alterations in bedrock.
- Cooperate with local developers and industry to minimize impact near park areas.

- Consult conservation groups regarding cooperative efforts to increase the areas of relevant parklands and protect more of the region around the park from development.
- Should streambanks affected by cattle grazing be remediated?
- Promote environmentally sound methods of developing land parcels including partial clearing of trees and proper construction of stable slopes.

## 7. Mine- related features

A historical depression within the park, now a vernal pool, may have been a borrow pit. Nearby stone quarries provided local building stones for Civilian Conservation Corps road building during the 1930's. Small- scale abandoned sand and gravel pits dot the landscape around Appomattox Court House National Historical Park. If historic, these features could be an interpretive program target. The state of Virginia has an inventory of mine features such as small open pit mines. Mines are constantly being identified and scanned into their database.

Research and monitoring questions and suggestions include:

- Comprehensively inventory mine- related features at Appomattox Court House National Historical Park, consulting aerial photographs and historic records if necessary.
- Consult the Virginia Department of Mineral Resources database for abandoned mine information.

## 8. Hydrogeologic system

The resource management needs to understand how water is moving through the hydrogeologic system into, under, and from the park. The geologic bedrock beneath this park is fractured and faulted. Such features provide quick conduits for water flow. Knowledge of the nature of the hydrogeologic system is critical to understanding the impacts of human induced contaminants on the ecosystem. The interaction between groundwater flow and the overall water quality should be quantitatively determined at the park. Little data regarding the nature of the hydrogeologic system at the park exists.

Park resource personnel also need to understand how the water table might change over time to manage water resources. Nearby cattle grazing threatens the groundwater quality in the area. There are several wells throughout the park that could be used for monitoring of ground water quality. It would be useful to perform tracer studies in these wells to see how quickly and in what direction water is moving through the system.

Research and monitoring questions and suggestions include:

- Inventory groundwater levels throughout the park.
- Test for and monitor organics (from agricultural and cattle waste), phosphate and volatile hydrocarbon levels in the groundwater at the park, focusing on areas near facilities and at boundaries near industrial sites and housing developments.
- Inventory and map any existing springs in the park, especially with regards to their potential historical importance.
- Test water quality at any existing springs in the park.
- Create hydrogeologic models for the park to better manage the groundwater resource and predict the system's response to contamination.

#### 9. Future facilities

Many geologic factors must be taken into account during decision making regarding siting future facilities. The development of visitor use sights including trails and picnic areas are now being considered by park management. High concentrations of shrink and swell clays could undermine any structure. Knowing the locations of springs and understanding the hydrogeologic system helps avoid problems with groundwater flow. Waste facilities should be sited taking hydrogeology into account as well as an understanding of the substrate.

Research and monitoring questions and suggestions include:

- Consult local geologic experts when planning future facilities at the park.
- Locate areas of high swelling clay concentrations, springs, groundwater flow, high slope, unstable substrate, etc. to avoid for future facilities.

## ***Scoping Meeting Participants***

NAME	AFFILIATION	PHONE	EMAIL
Rick Berquist	Virginia Division of Mineral Resources	757- 221- 2448	rick.berquist@dmme.virginia.gov AND crberq@wm.edu
Mark Carter	AASG- Virginia Division of Mineral Resources	434- 951- 6357	mark.carter@dmme.virginia.gov
Jim Comiskey	NPS, MIDN	540- 654- 5328	jim_comiskey@nps.gov
Tim Connors	NPS, Geologic Resources Division	303- 969- 2093	tim_connors@nps.gov
Brian Eick	NPS, APCO		brian_eick@nps.gov
Stephanie O'Meara	NPS, Natural Resources Information Division	970- 225- 3584	Stephanie_O'Meara@partner.nps.gov
Trista Thornberry-Ehrlich	Colorado State University	757- 222- 7639	tthorn@cnr.colostate.edu

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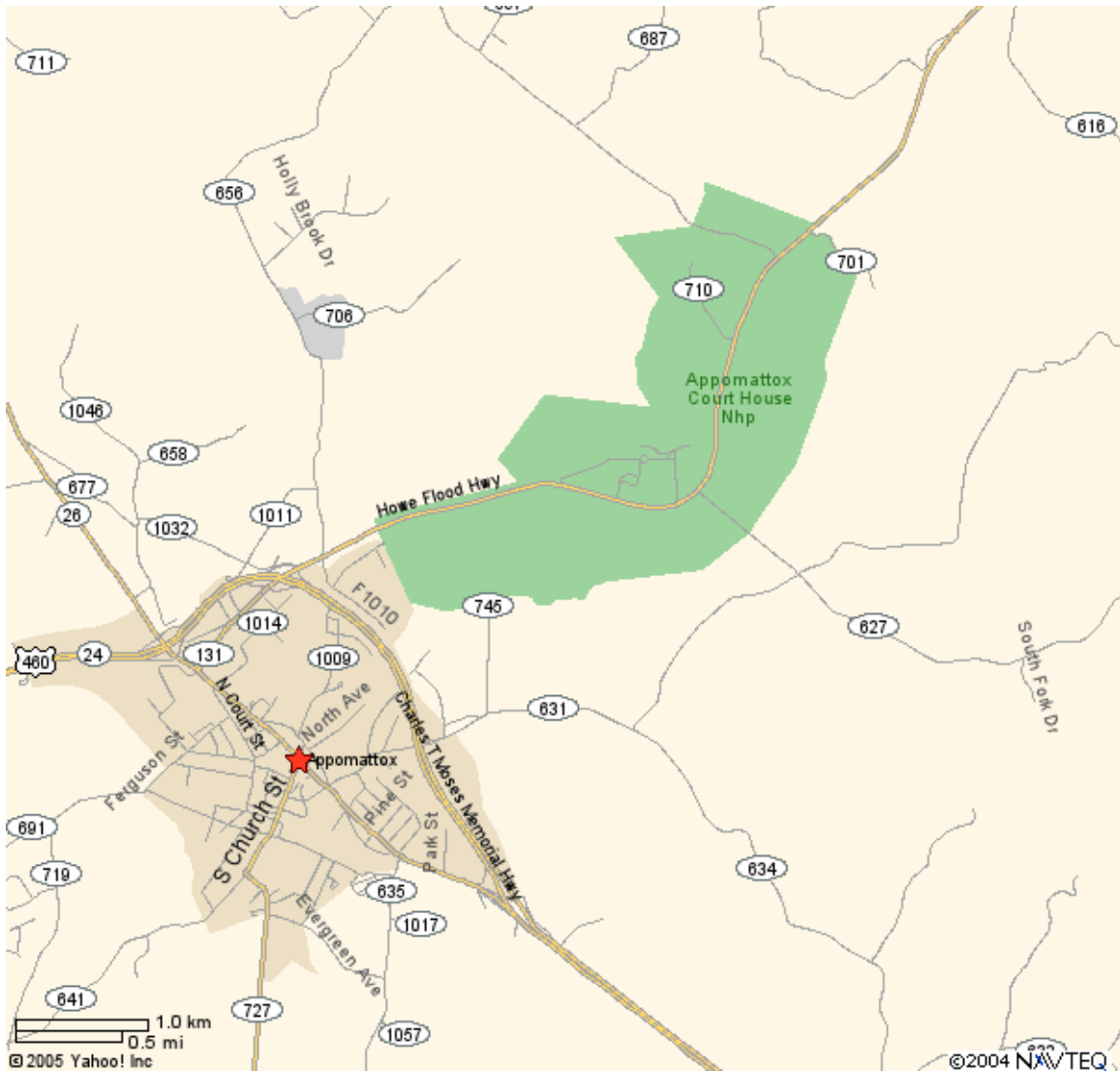
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***Map of Appomattox Court House National Historical Park***



Map courtesy of Public Broadcasting Service, 2002.



Map courtesy of Yahoo.com, 2005